

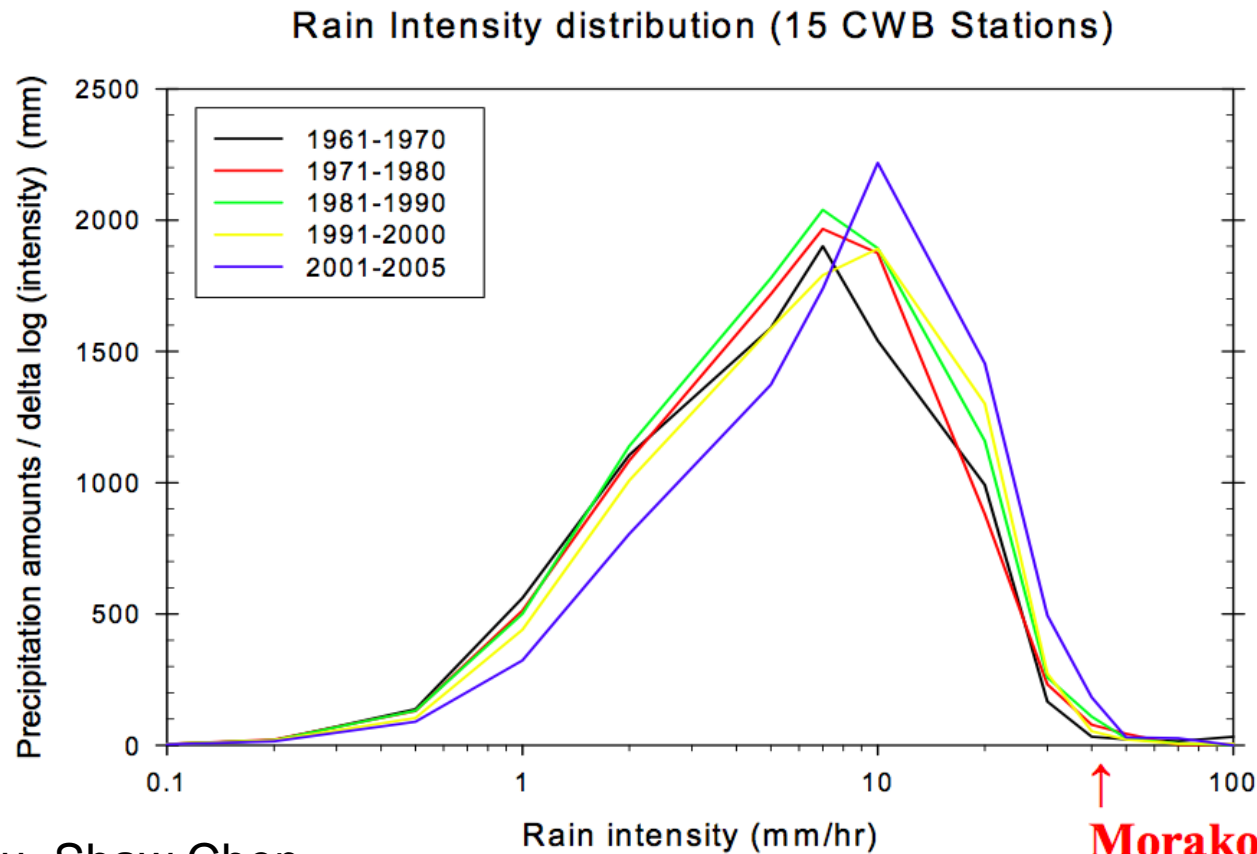


# **Recent unusually high extremity of Taiwan rainfall extremes and the modulation of Interdecadal Pacific Oscillation**

**Mong-Ming Lu**  
**Central Weather Bureau, Taiwan**

**Co-authors: Ching-Teng Lee**  
**Yun-Ching Lin**

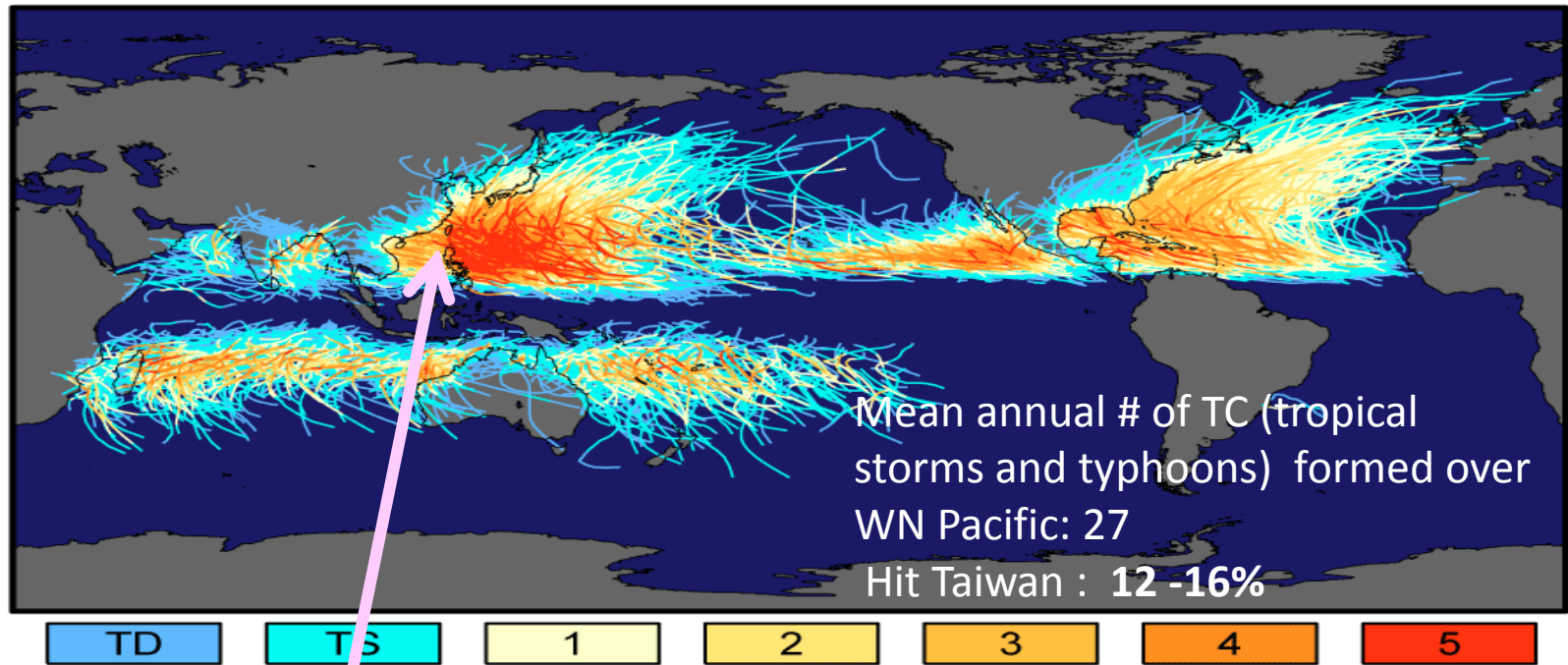
- Changes of the rainfall extremes is a most concerned climate issue in Taiwan.
- Rainfall data shows increasing rain intensity since 1961.
- Typhoon Morakot in 2009 took at least 600 people in Taiwan by deadly landslides.



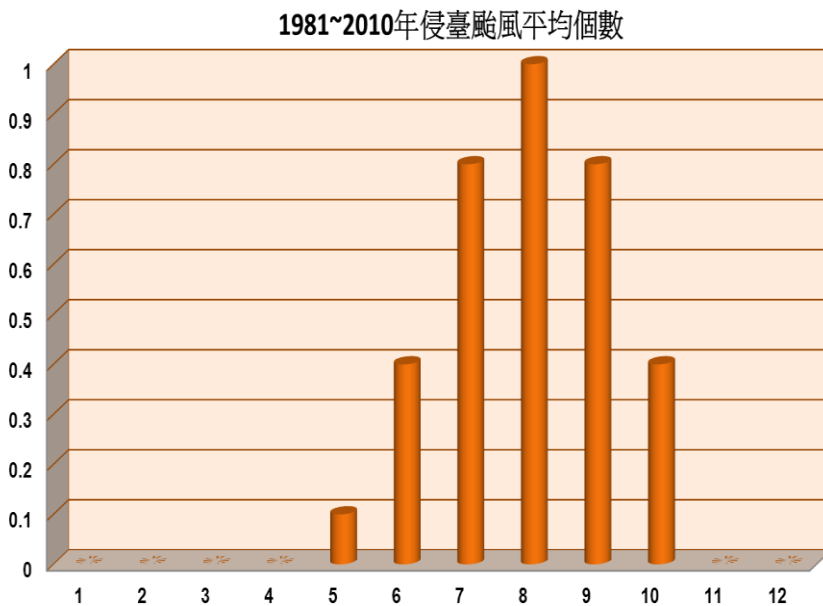
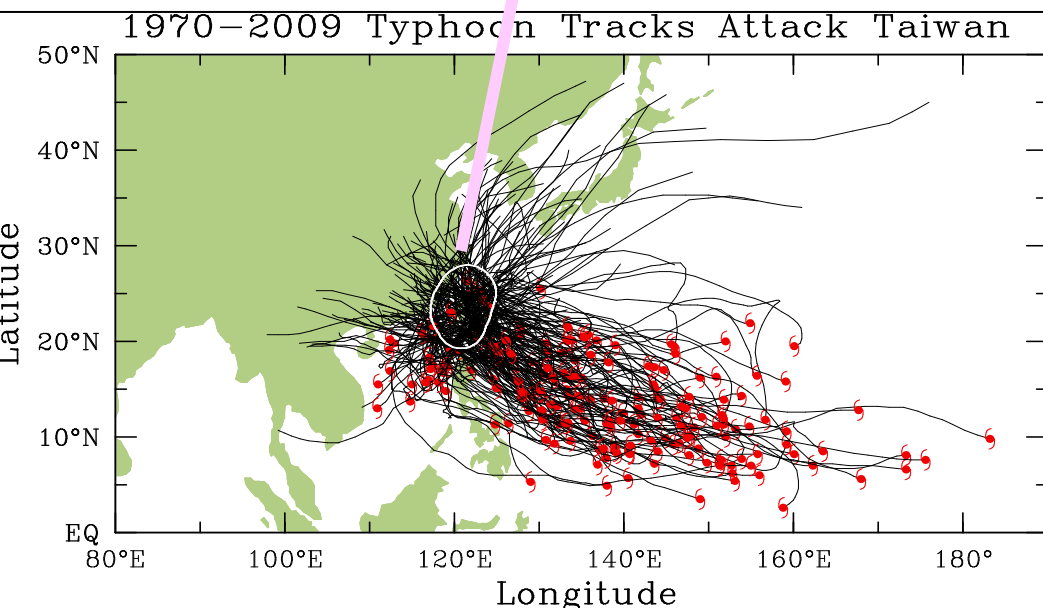
From: Liu, Shaw Chen

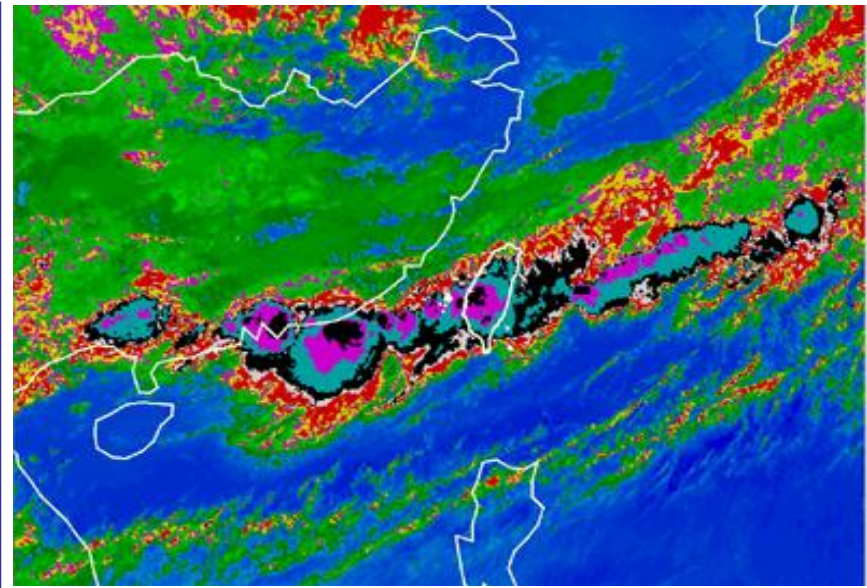
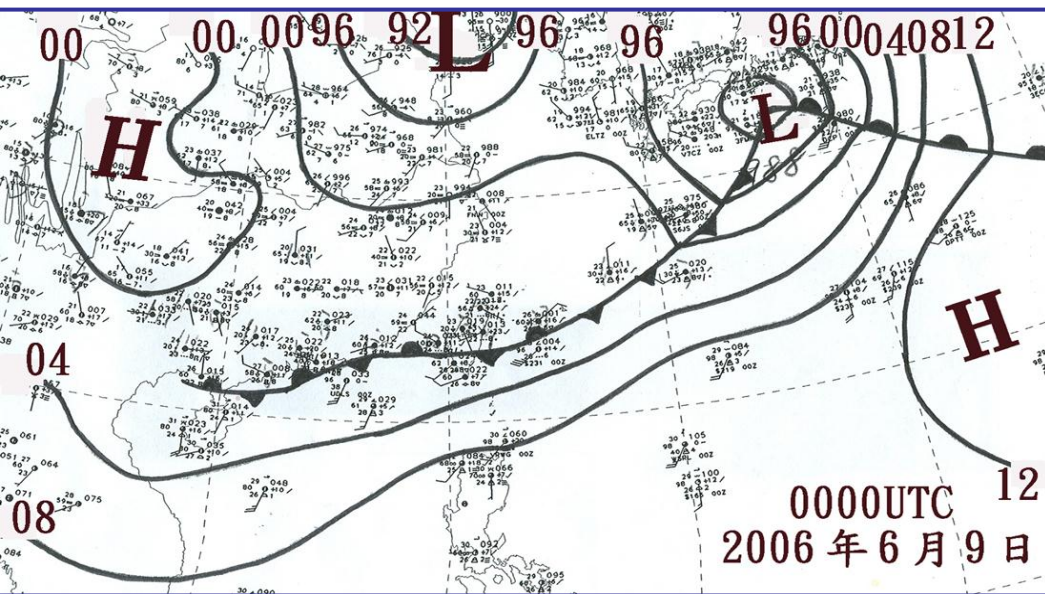
**Morakot In 2009**  
> 600 death

# Tracks and Intensity of All Tropical Storms

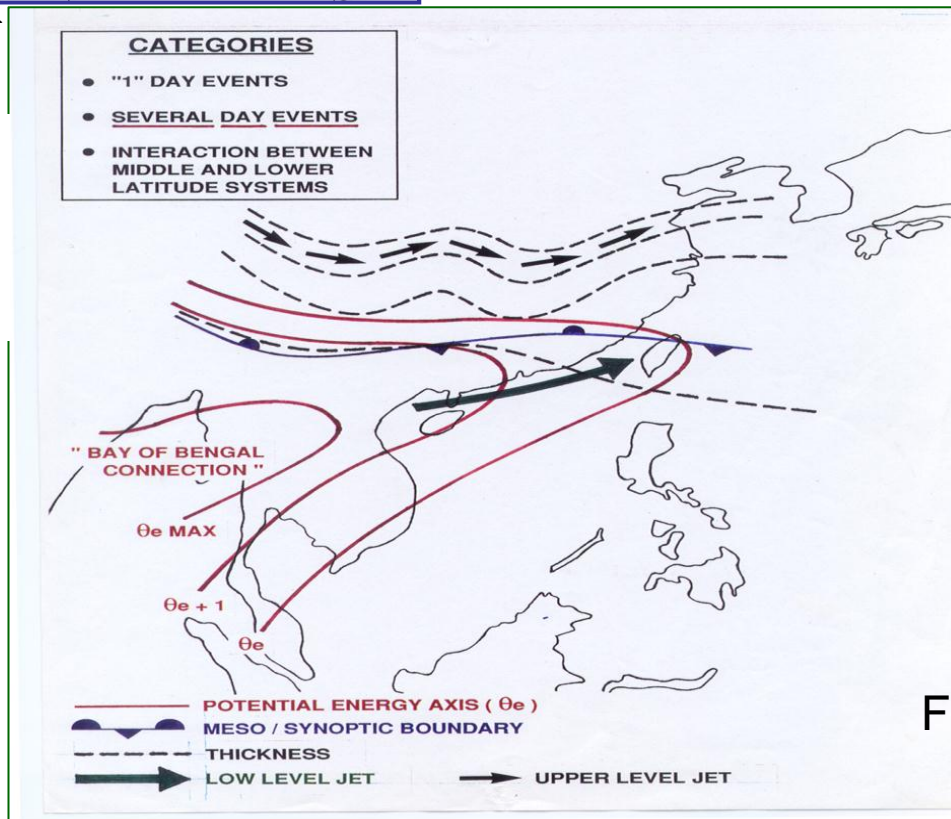


## Saffir-Simpson Hurricane Intensity Scale





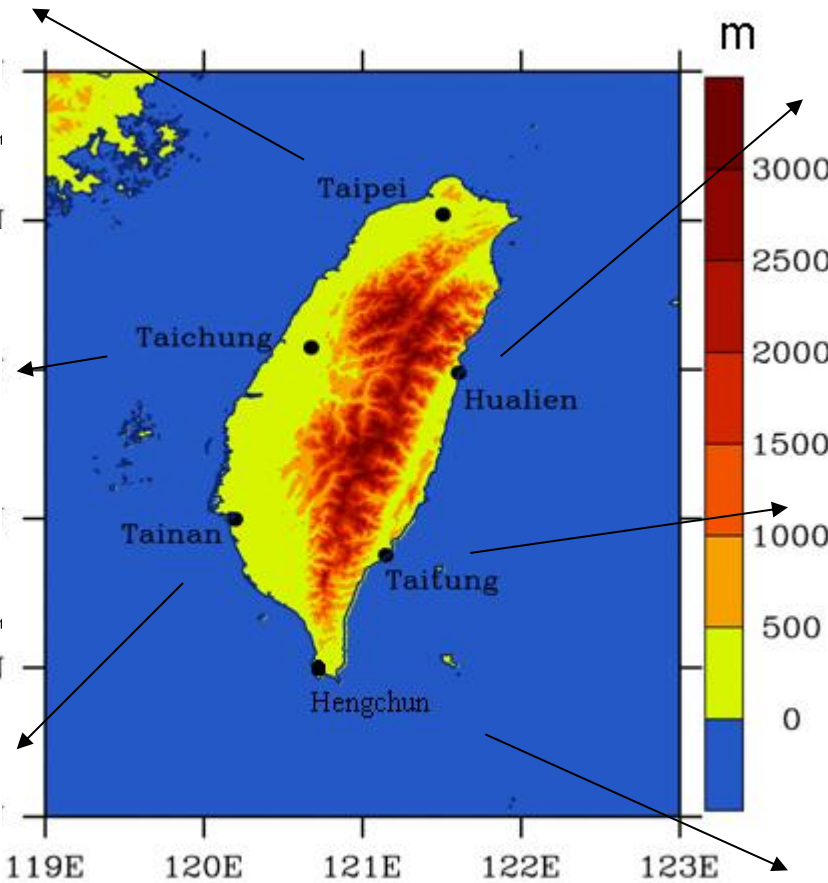
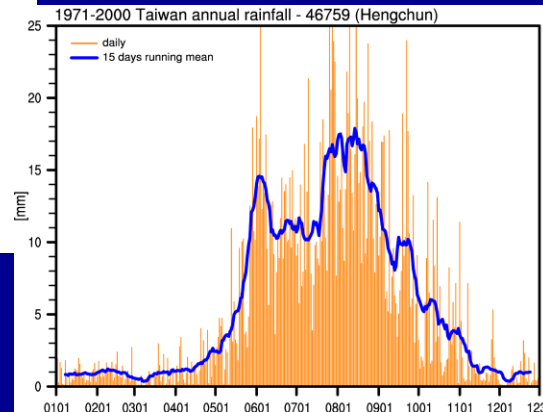
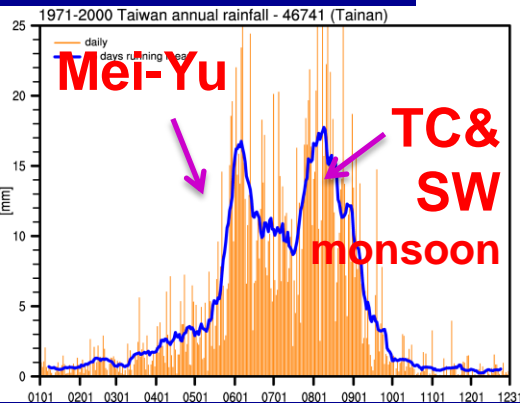
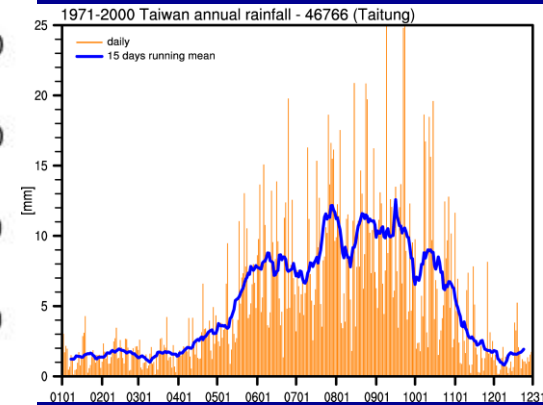
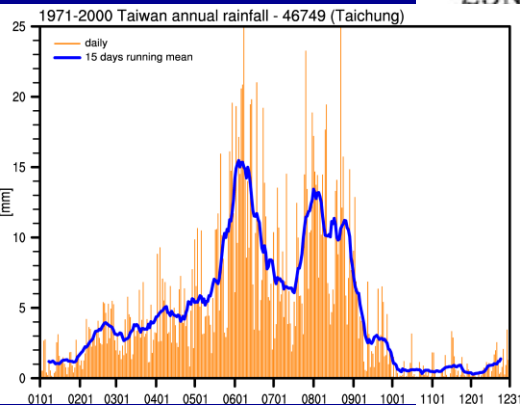
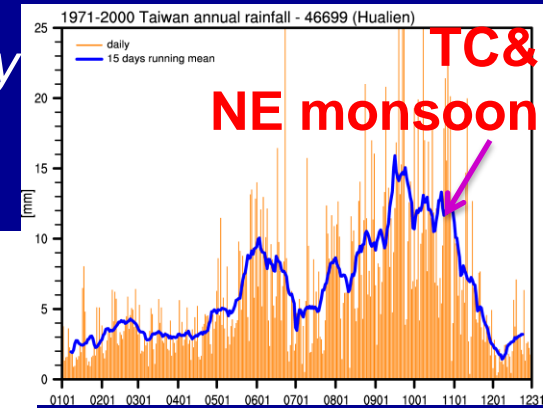
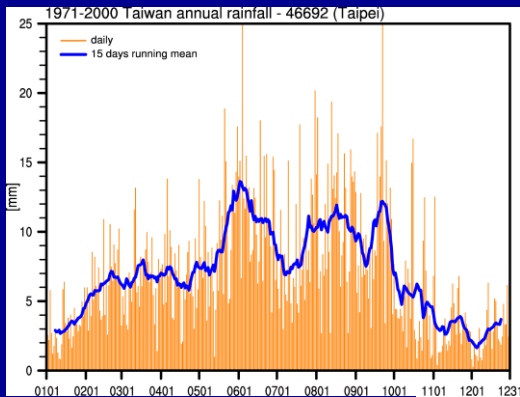
# Taiwan Mei-Yu May-June



From: S.S. Chi  
紀水上



# Taiwan rainfall climatology - daily (orange) & pentad (blue)



# ***More frequent extreme events in the warm climate ?***

to quantify the interannual variations of the extreme rainfall event frequency ....

## **Define “extremity” index**

**EERF** (Extremity of the Extreme Rainfall Frequency) – the **annual** total count of the extreme rainfall events. Unit: events/year

## **Extreme Rainfall Event -**

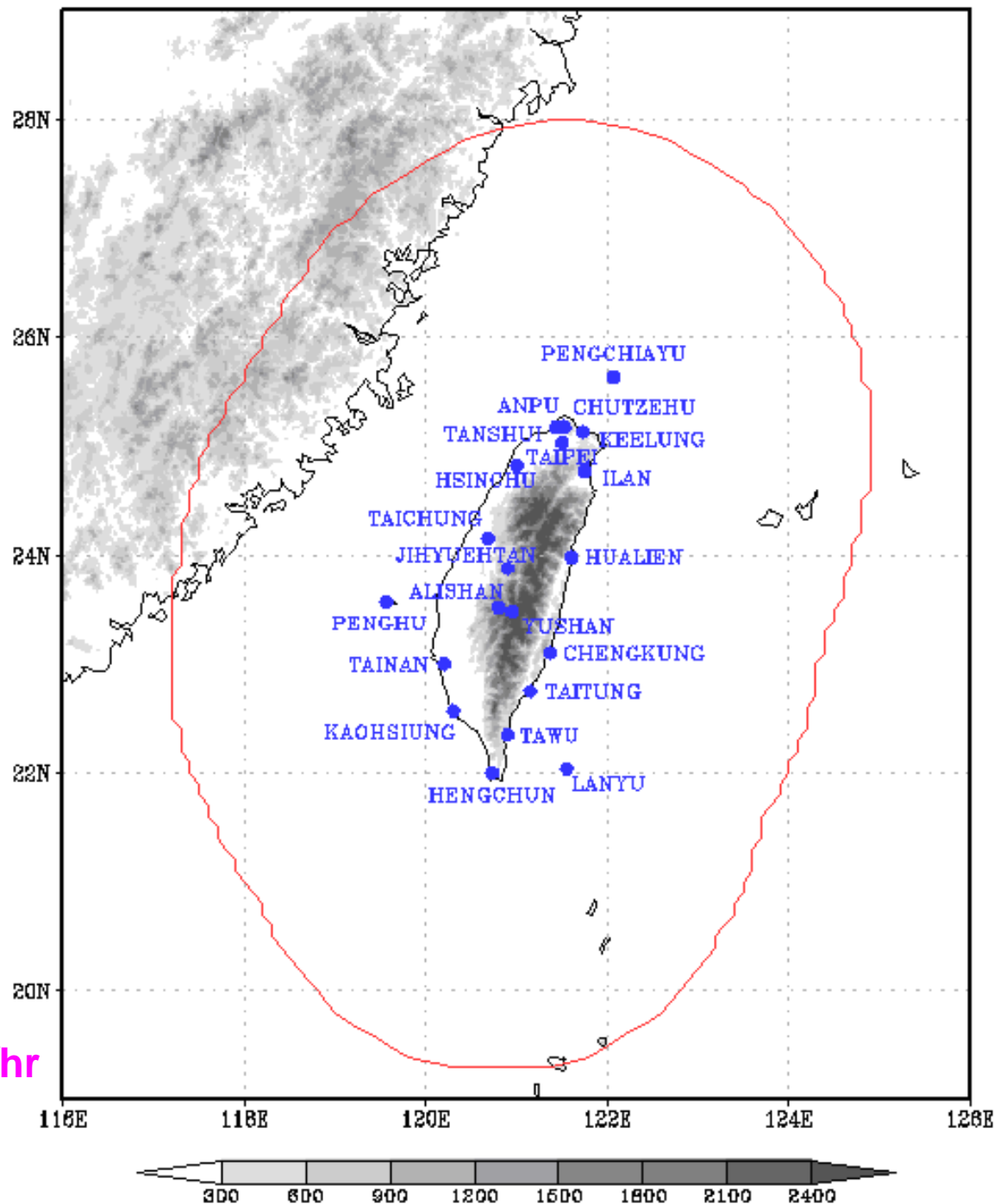
a rainfall event that the amount of rain is larger than the biennial maximum event (the return period  $> 2$  years / the two-year event) estimated by the extreme value statistics at each **station** based on the 50 years (1961-2010) of hourly data.

# Data

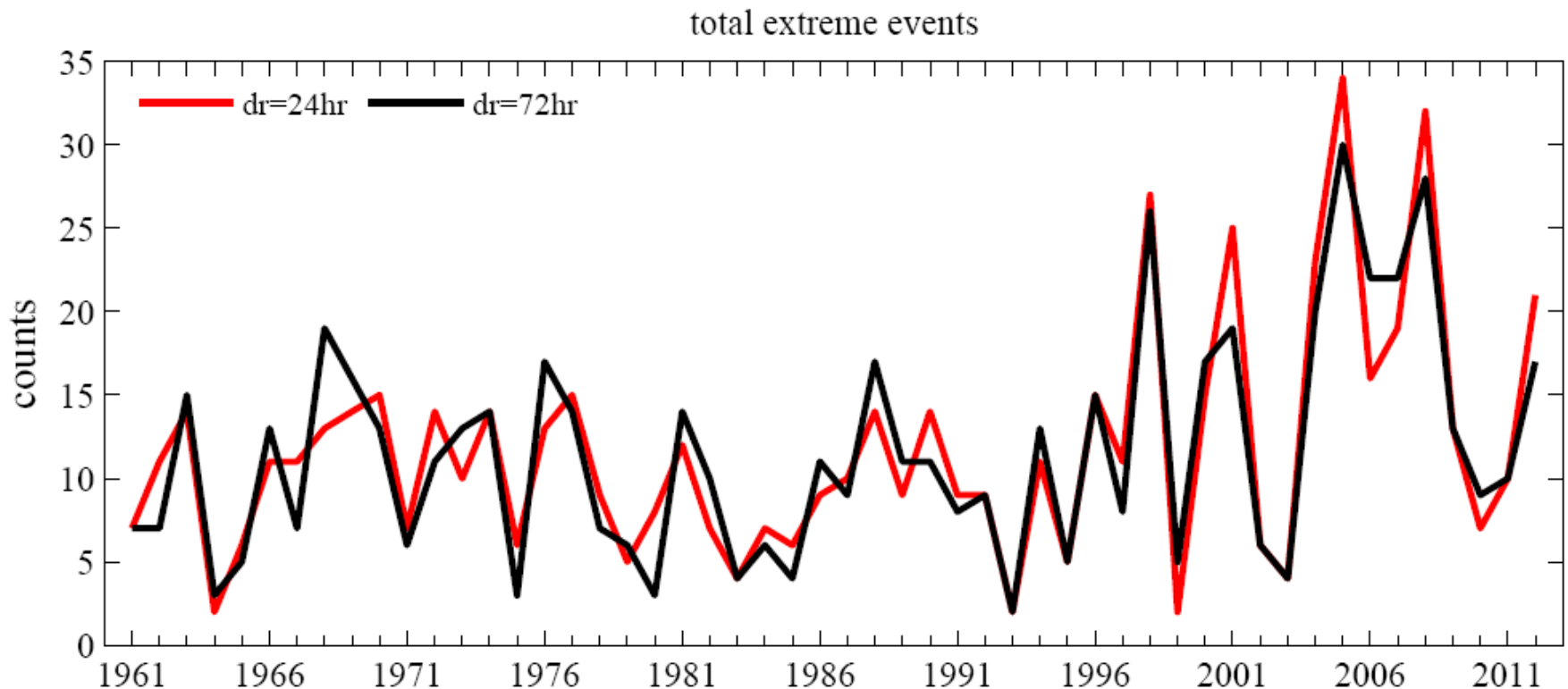
1. The 52-year **hourly rainfall data** at **21 stations** during the period of **1961-2012** are analyzed.

2. **Typhoon rainfall events** are identified according to whether a typhoon center can be identified within the **300 km** boundary marked by the red circle. The typhoon information is obtained Joint Typhoon Warning Center website ([http://metocph.nmci.navy.mil/jtwc/best\\_tracks/](http://metocph.nmci.navy.mil/jtwc/best_tracks/))

**Note:** Only the data with measurement larger than **5mm/hr** is included when analyzing the statistics of the extreme events.

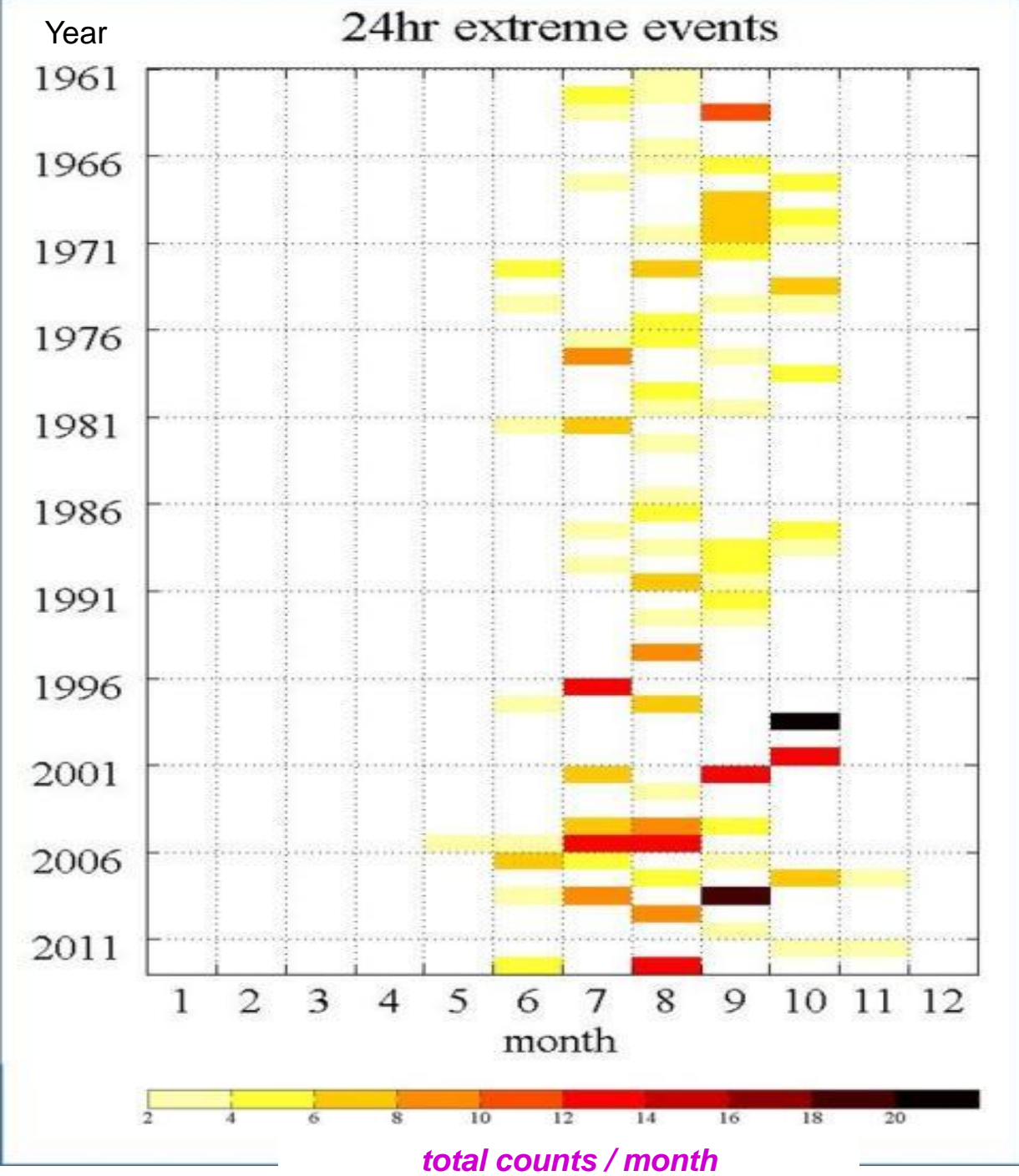


## Variations of the Extremity of Taiwan Rainfall Extremes represented by index EERF

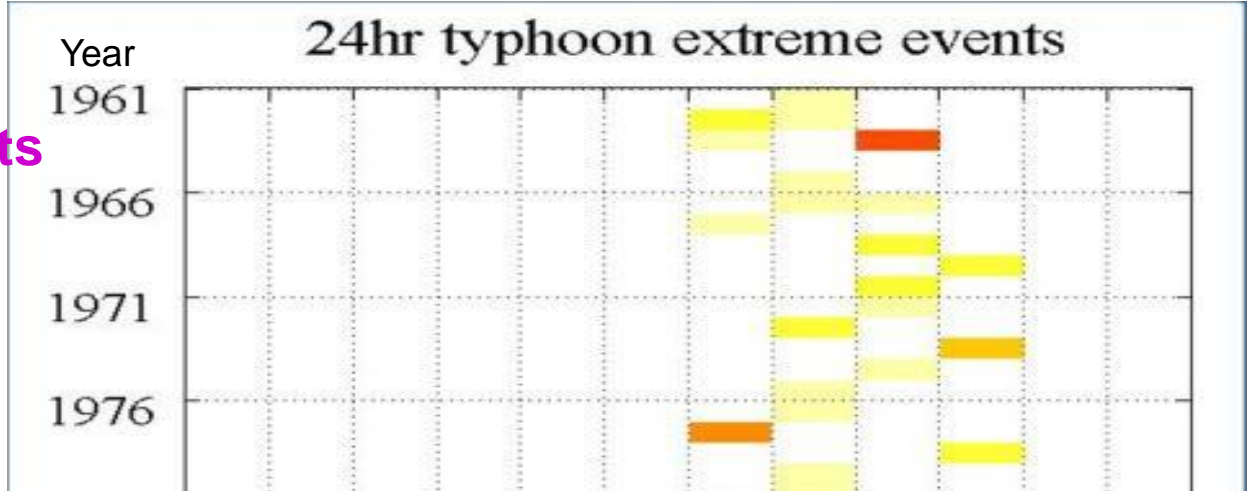




Counts of the extreme rainfall events per month

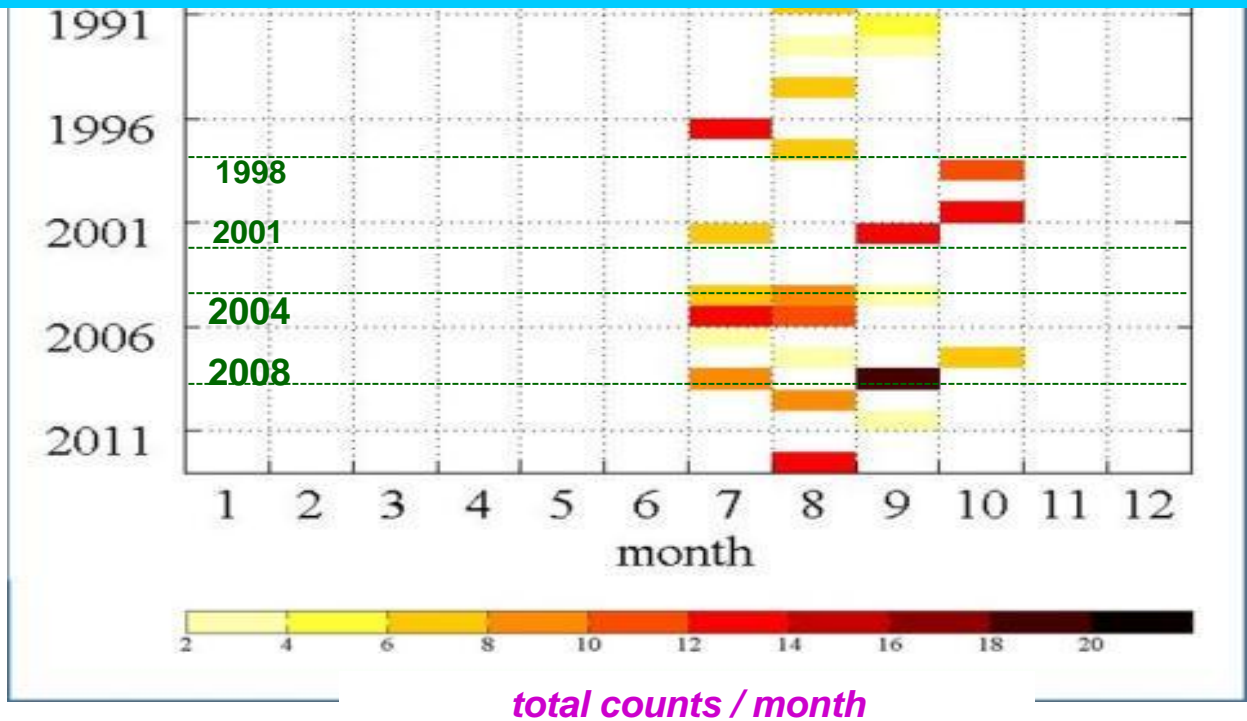


# TYPHOON extreme rainfall events



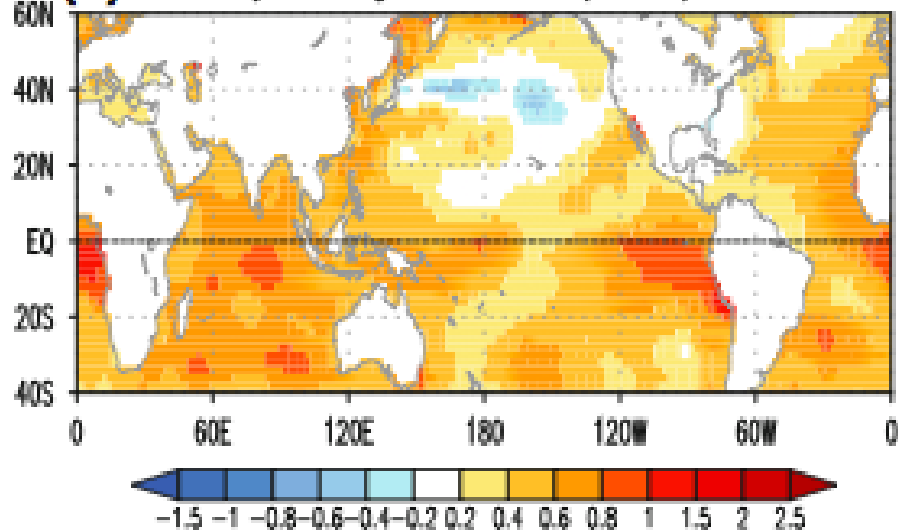
## WHY ?

*Unusual seasons:*  
 Sep-Oct (1998-2001)  
 Jul-Sep (2004-2008)  
 Aug (2009-2013)

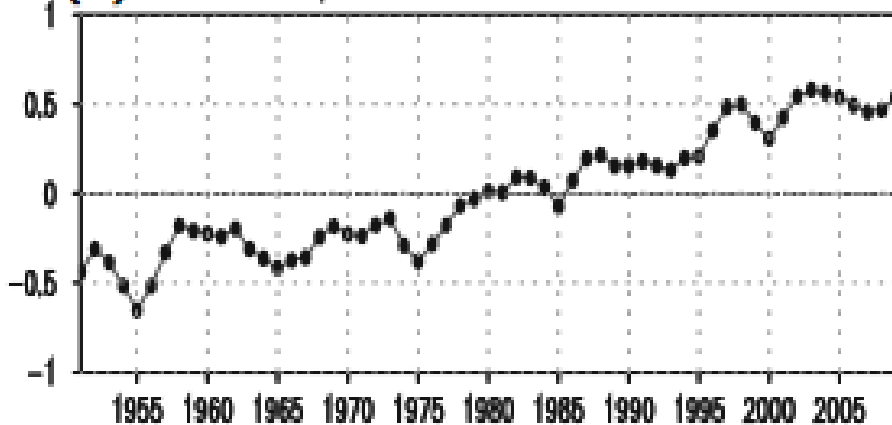


## Global Warming

**(a)** EOF1 3-yr running mean ERSST (39.2 %)

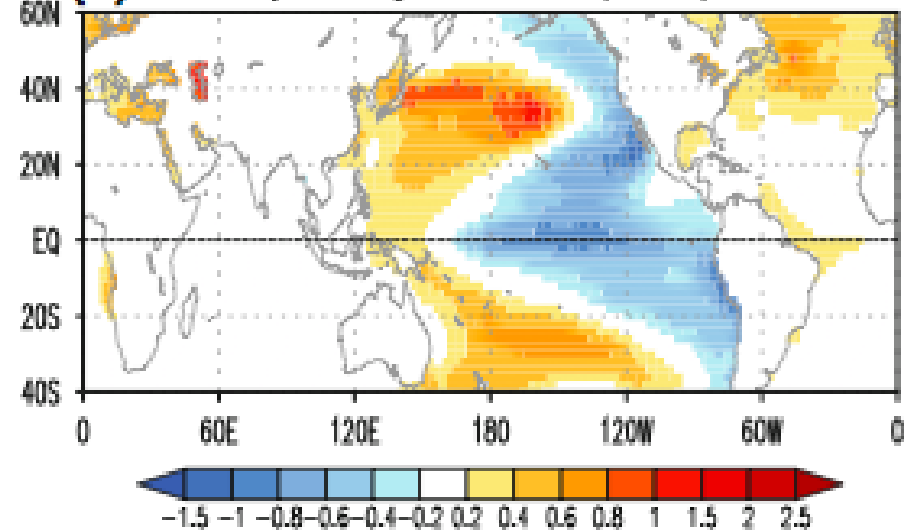


**(b)** EOF1 time expansion coefficient

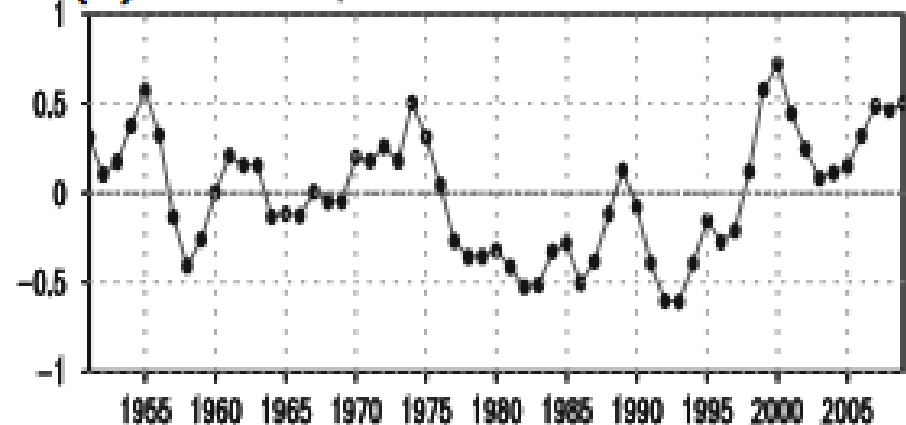


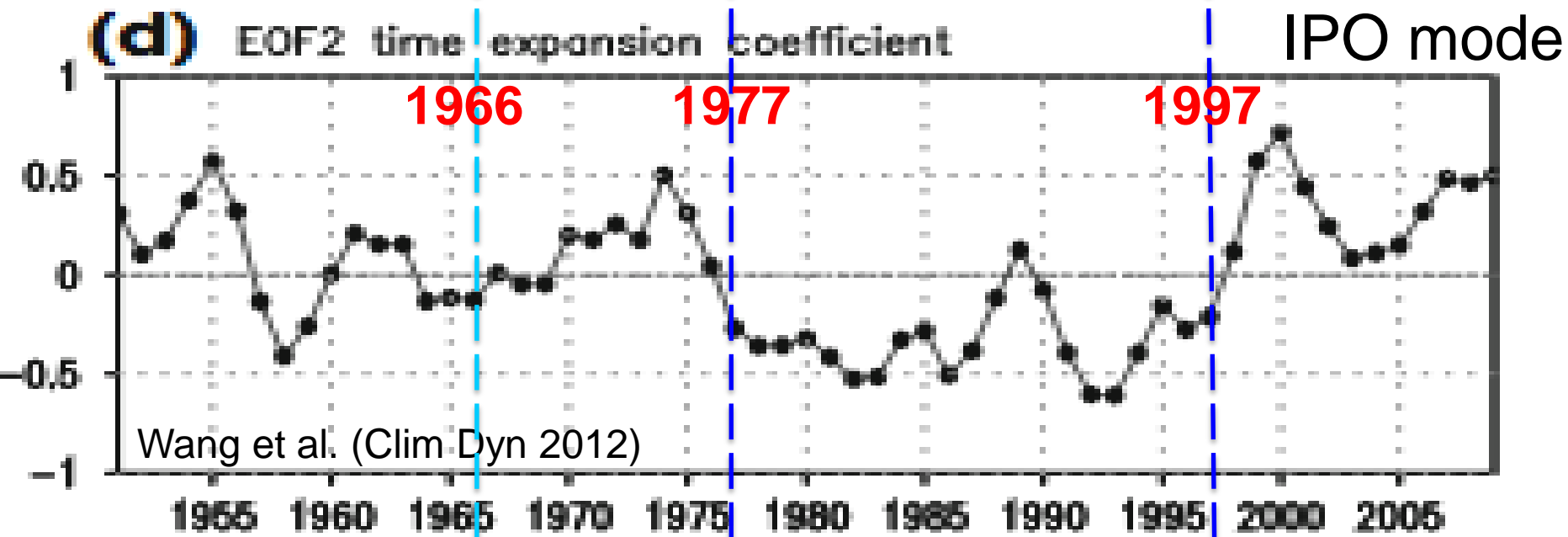
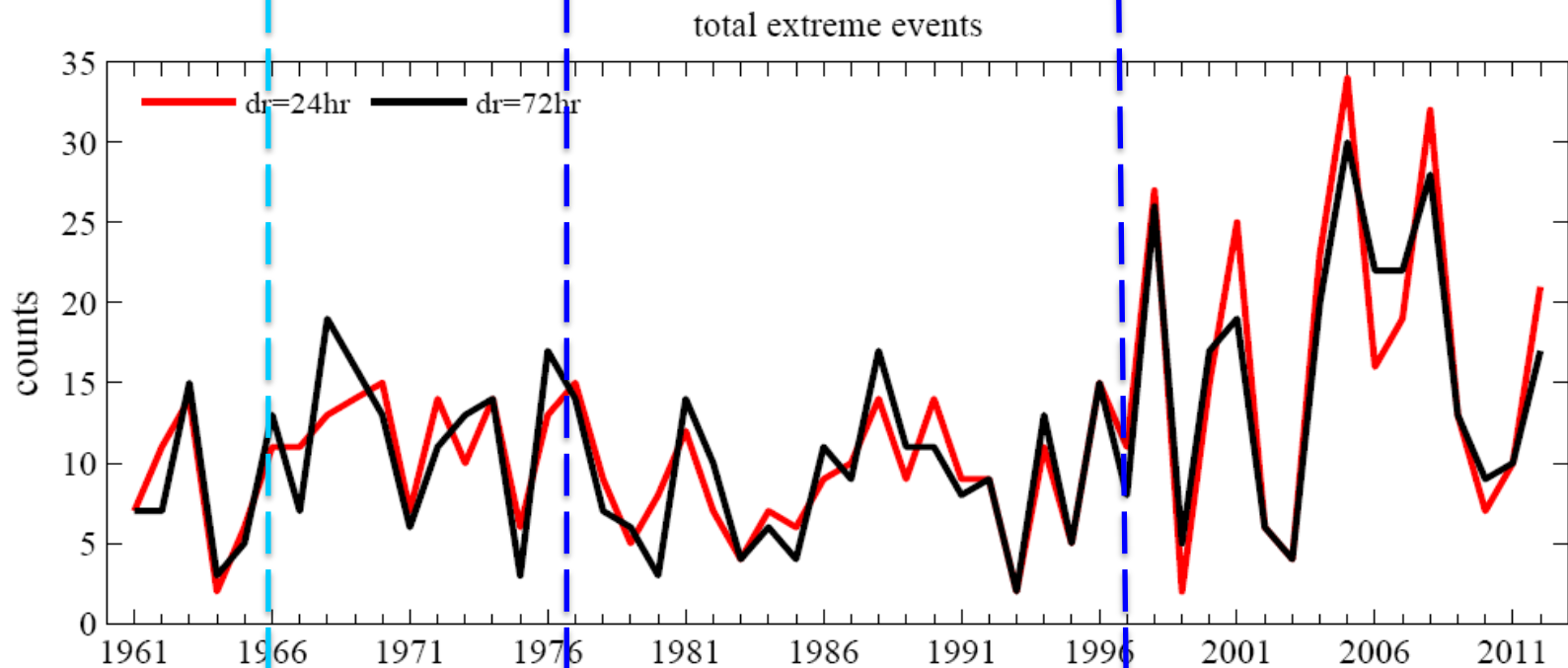
## Interdecadal Pacific Oscillation

**(c)** EOF2 3-yr running mean ERSST (20.0 %)



**(d)** EOF2 time expansion coefficient





## extreme rainfall events

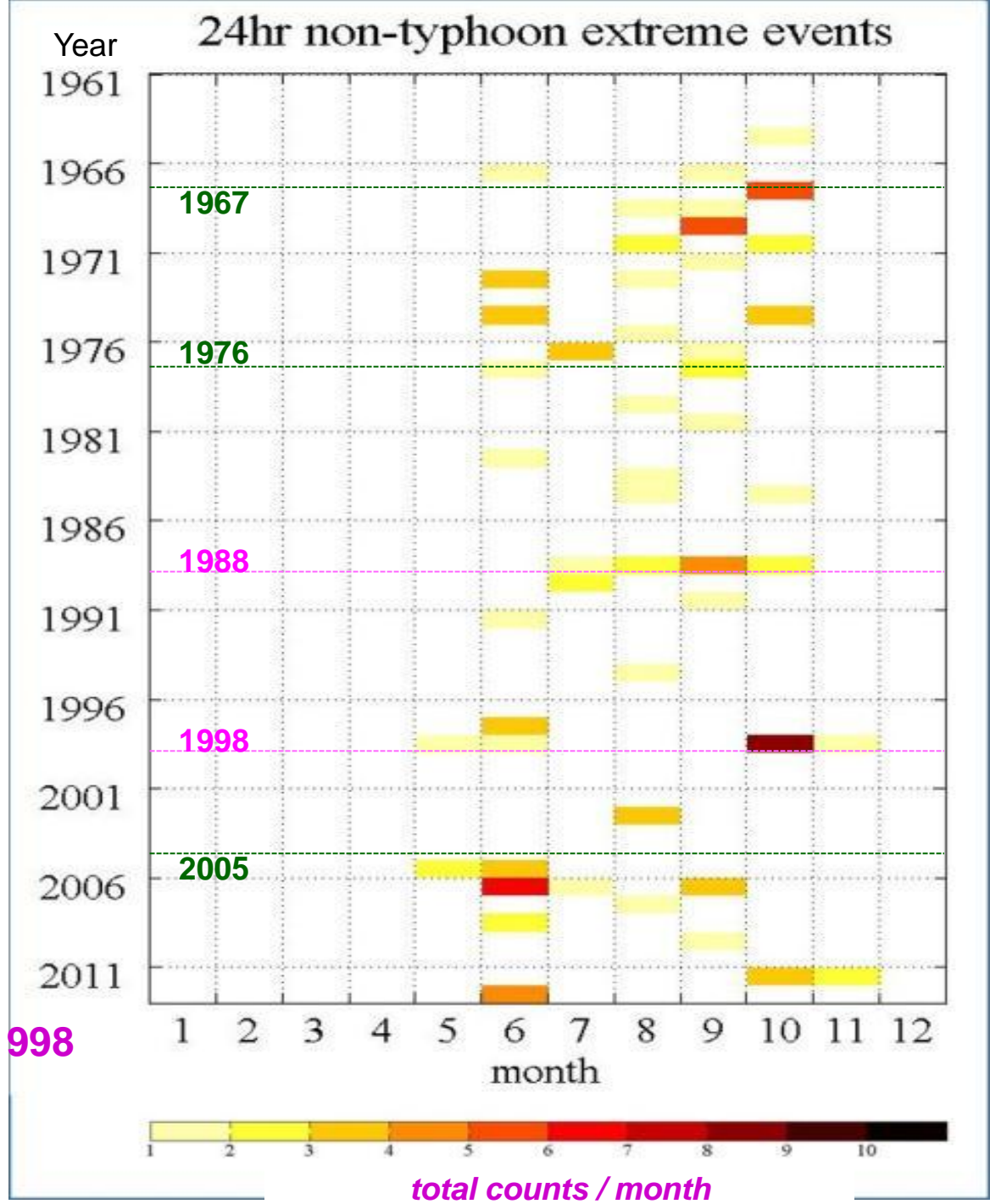
## Active periods :

## Sep-Oct (1966-1977)

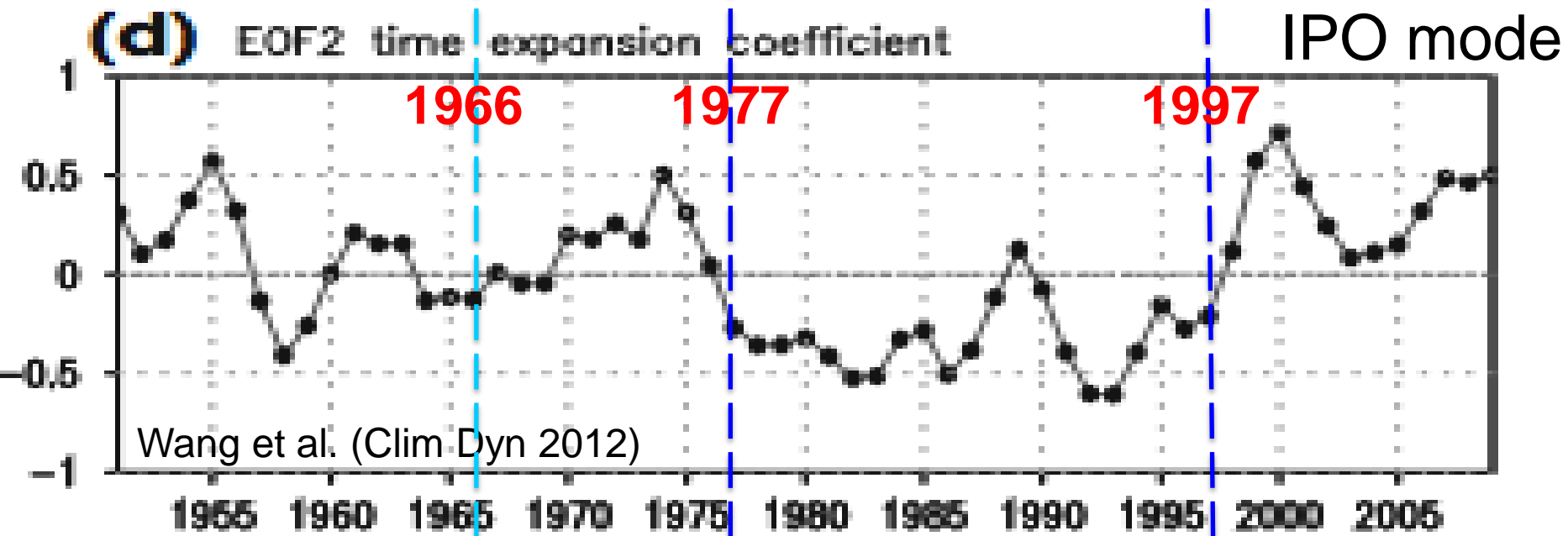
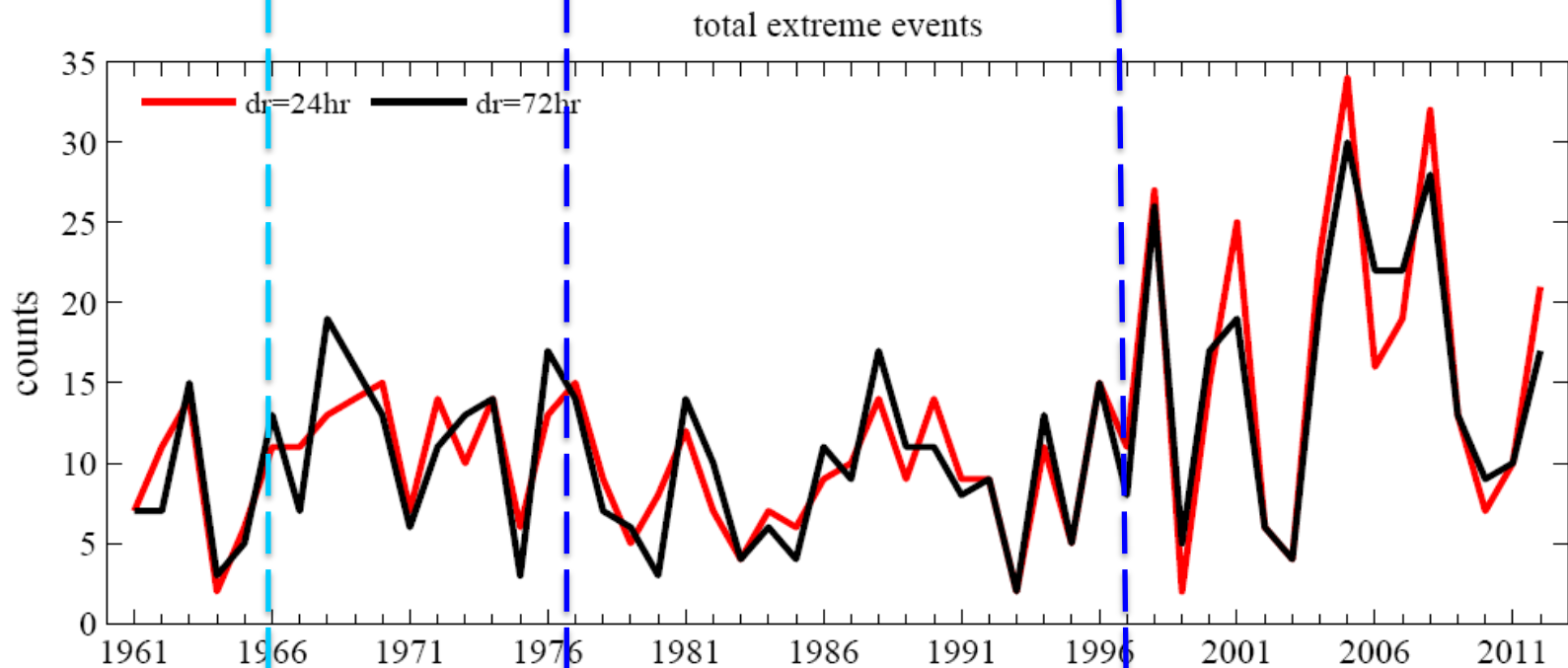
## June (2005-2013)

## Quite period:

1978-2004 except 1988, 1998





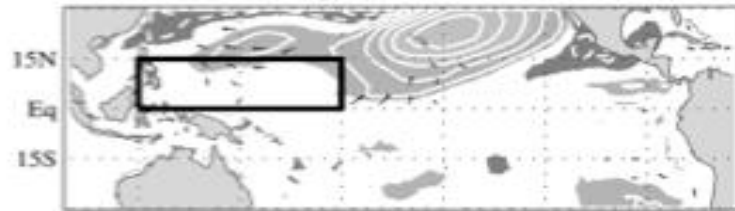


# Summary

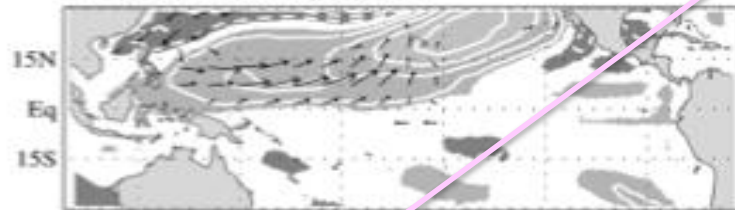
- The 52-year (1961-2012) variations of the extremity index **EERF** indicates a sudden jump of the rainfall extremity in Taiwan after **1997**.
- The unusually frequent occurrence of the extreme rainfall events is attributed to the intensification of the Global Monsoon Precipitation driven by **the Inter-decadal Pacific Oscillation** of the SST and **global warming**.
- The **active** (**1967-1976**) and **inactive** (**1977-2004**) periods of the non-typhoon (i.e. monsoon) type of extreme events are coherent with the rhythm of Global Monsoon Precipitation variations.
- The unusually active years (**1988**, **1998**) during the inactive periods reflect strong **ENSO – East Asian monsoon** connection.
- For further forecast applications, **the western North Pacific subtropical high** that connect Pacific SST and Taiwan weather is a key.

## Response to NPO Forcing SST, >850mb Wind

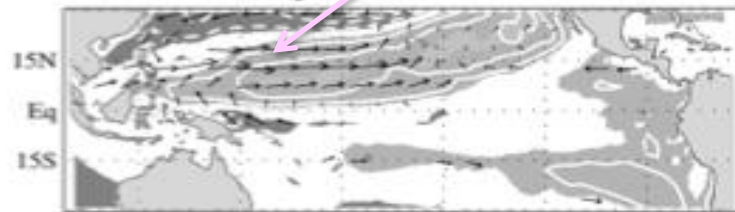
a. JAN–MAR (year 1)



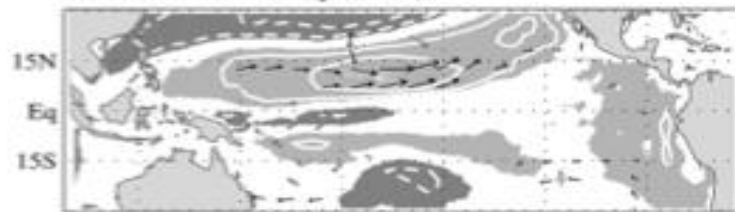
b. APR–JUN (year 1)



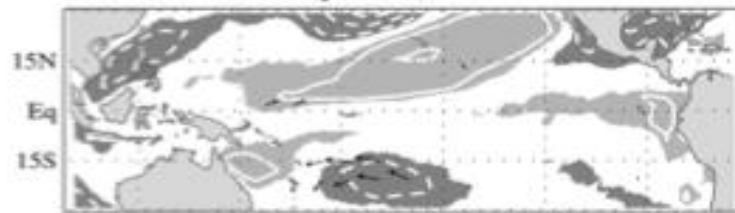
c. JUL–SEP (year 1)



d. OCT–DEC (year 1)



e. JAN–MAR (year 2)



120E 150E 180 150W 120W 90W  
Contour: 0.2°C Scale: 1 m/s = →

**Western North Pacific Subtropical High –**  
a key controlling factor of typhoon and monsoon  
influence on Taiwan

Vimont et al. (J Climate 2009)

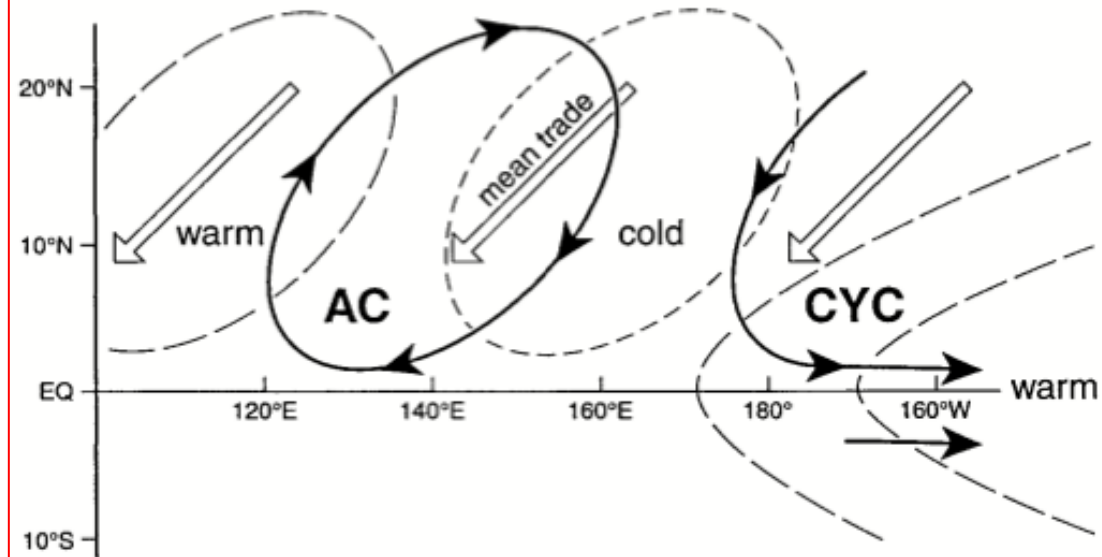


FIG. 16. Schematic diagram showing the air–sea interaction in the western North Pacific that maintains the Philippine Sea anticyclonic anomalies and associated negative SST anomalies in the western North Pacific. The double arrows denote the mean trade winds. The heavy lines with black arrows represent the anomalous winds. The long (short) dashed lines indicate contours of positive (negative) SST anomalies.

Wang et al. (J Climate 2000)



.....THANK YOU 謝謝 THANK YOU 謝謝 ...



竹子湖氣象站